Mech Warrior Costume

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PARTS:

- 1/2" PVC pipe, 10' length (2)
- 5 Gallon Homer Bucket (2)
- 2 gallon bucket (2)
- 1/2" PVC 45 degree elbow (12)
- 1/2" PVC 90 degree elbow (8)
- 1/2" PVC tee fitting (8)
- 1/2" PVC end cap (7)
- #10-24 x 6" machine bolt (6)
- poster board sheet (1)
- 3/8" foam core board (1)
- #10-24 x 2.5" machine bolt (4)
- #10-24 x 4" machine bolt (2)
- #10-32 x 2" machine bolt (6)
- #10-24 x 1.5 machine bolt (10)
- 3/4" x 6' foam pipe insulation (1)
- #10-24 x 2" machine bolt (2)
- Duct tape (1)
- #10-24 machine bolt nut (30)

- #10 washer (24)
- #10-32 machine bolt nut (6)
- 1/2" wooden dowel (1)
- 1" wood screws (2)
- nylon twine (1)
- silicone spray (1)
- Glue (1)
- non-skid shoe pads (1)

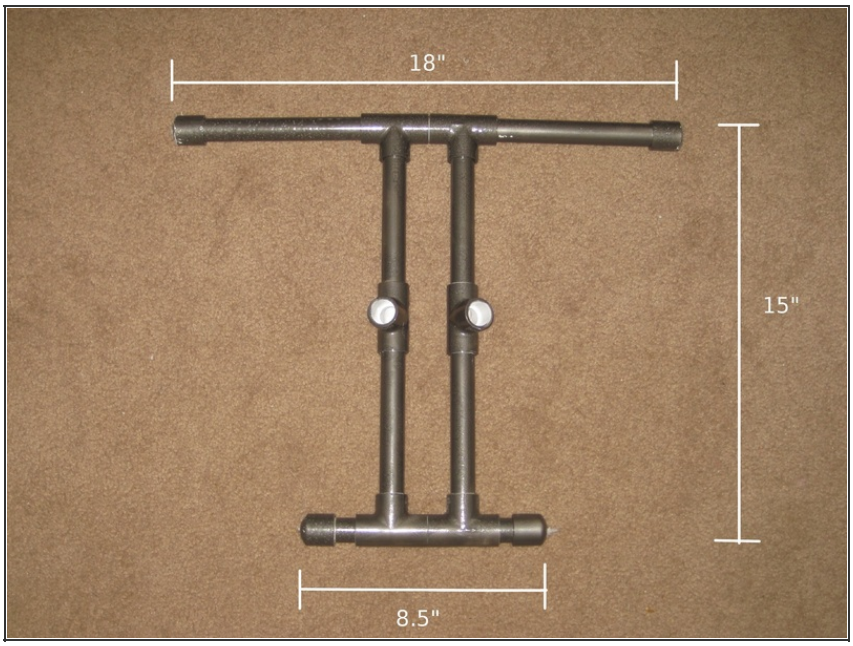
SUMMARY

Inspired by a robot exoskeleton built by some Japanese college students that was online recently, I really wanted to try building one myself. My son decided he wanted to help and then wear it for Halloween.

We did the arms the same way they did but decided to do the legs as bucket stilts; it would be a simpler design and safer in PVC, I thought. We did one working hand and the other as a fist so it could hold a Halloween bucket. The working hand is still more decorative than functional but the fingers do flex. This project is moderately difficult; no step is particularly hard but there are sure a lot of them.

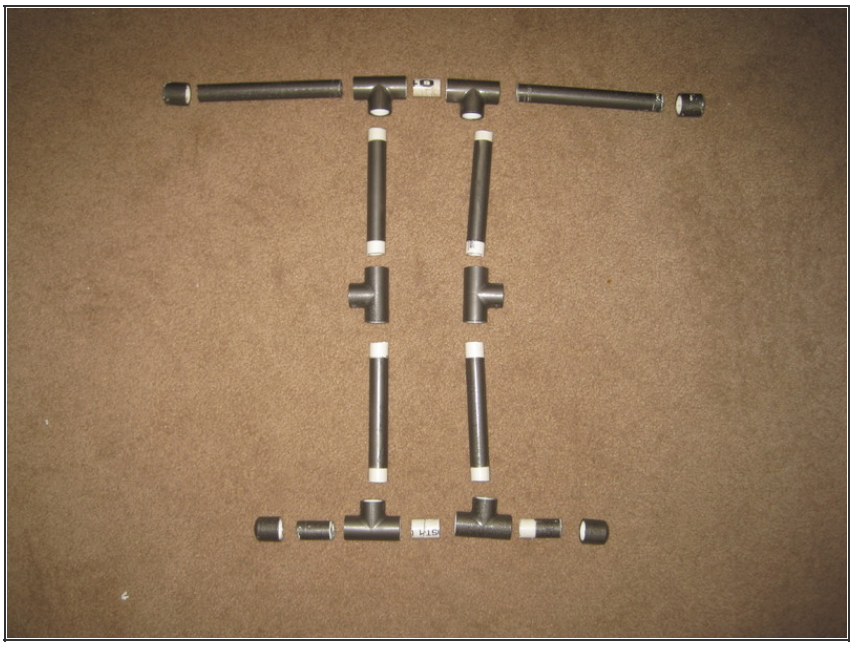
The pictures I took during the build turned out to be not as useful as I hoped. We were in such a rush to finish before Halloween that we didn't take enough. Also, the design changed some as we built it so some of the pictures were no longer useful. For these instructions I took the costume apart and took pictures during the process. The only thing different in the pictures is that everything is painted. In reality nothing was painted until listed in the instructions at step 17.

Step 1 — The Frame



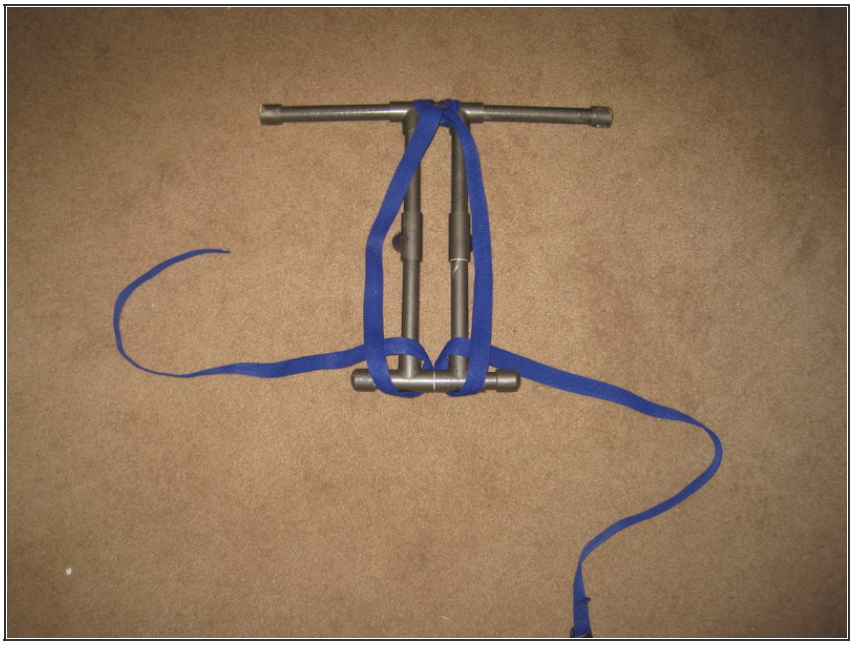
- The first step is to get some measurements for the frame. The frame is going to be worn sort of like a backpack and will keep everything connected. It needs to go from the top of his shoulders to just above his hips (NOTE: this was made for our son, so we will refer to the wearer as a boy). We found there's a balance when picking the shoulder width: narrower allows him to reach his arm farther but also causes his arms to frequently brush his legs. We measured his shoulders at 13" and made the frame shoulders 18".

Step 2



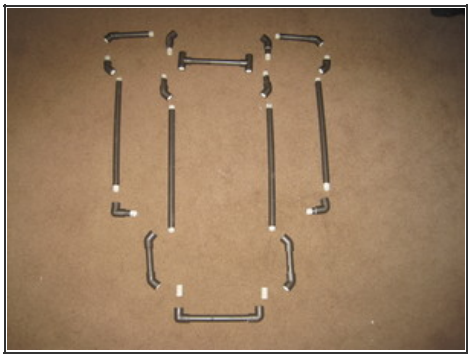
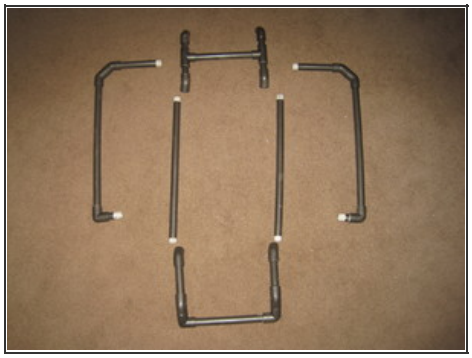
- When cutting the PVC remember that you'll lose some of the length inside the fittings. I seem to lose between 5-6 eighths. I'm sure there's an exact measurement but between imperfect cuts and sticky joints it never seems to be exact.
- We didn't end up using PVC glue for anything since we liked the ability to disassemble the unit. Occasionally a fitting needed tightening, but the costume worked fine without it. If you decide to use glue, we recommend holding off until the end, when it will be clear which pieces should be removable.

Step 3



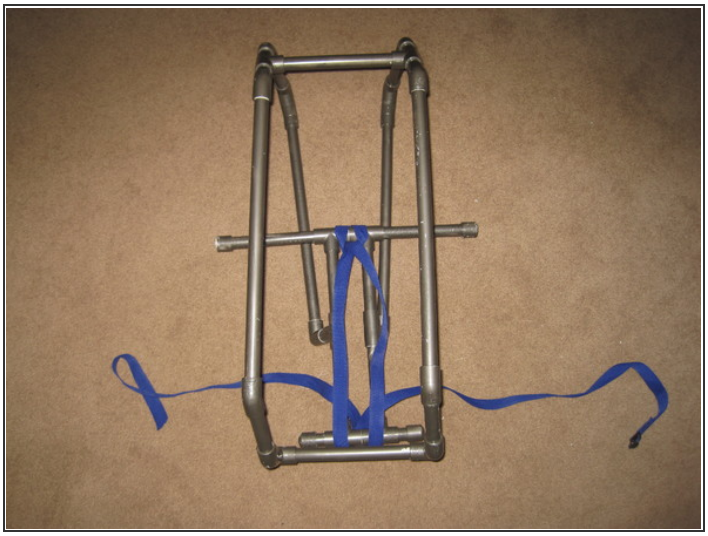
- The final step for the frame is to attach some straps so that it can be worn on his back. I started with rope, which worked OK, but switched to some nylon belting so it was more comfortable on his shoulders. I simply put it in a lark's head at the top and wrapped it around the bottom. It then goes around his waist and buckles in front.

Step 4 — The Cage

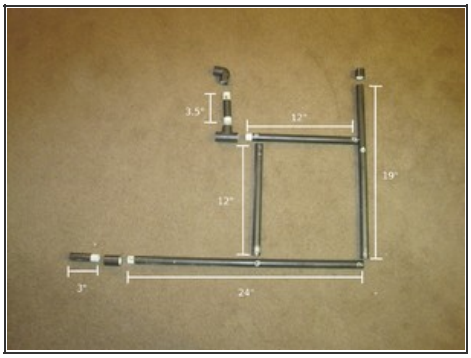

- The cage will connect to the frame in the back and wrap over his head. The crossbar in the front just rests on his waist.

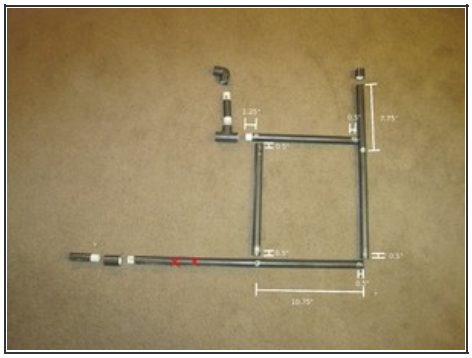
Step 5

- Attach the cage to 2 tee fittings in the middle of the frame.

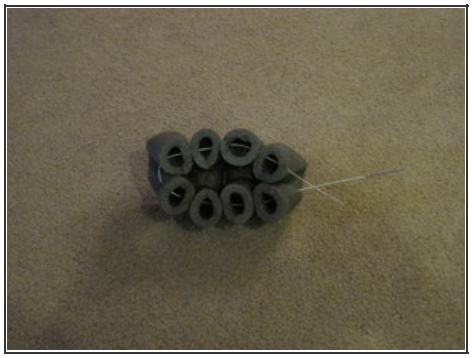
Step 6 — The Arms





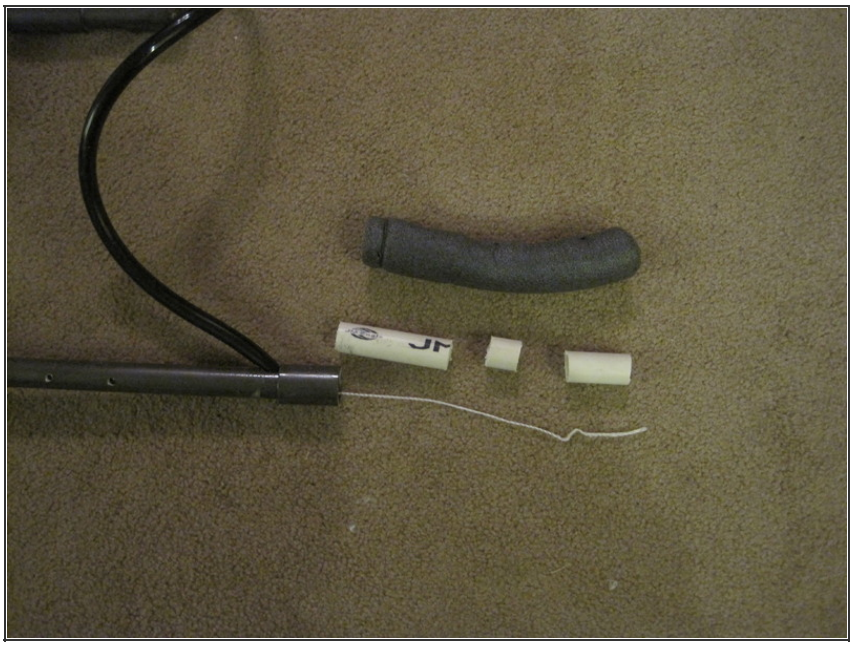

- I measured his arm from elbow to wrist at about 12 inches and wanted the robot arm to be about twice that length. The PVC pieces were cut to the dimensions shown. In the first picture the top horizontal pipe lines up with his elbow to wrist and the lower pipe is the robot elbow to wrist.
- We used a 7/32" bit to drill the holes. There are 2 holes in each of the four pieces of the arm skeleton (to be added later in the build). Frame 2 shows the approximate location of those holes, marked by the red x's.
- We found it best to attach the PVC as shown with the piece at the bottom of the picture stacked the highest and the topmost the lowest. It was the most comfortable this way. The pieces are joined by three 6" bolts on the outside and a 2.5" bolt on the inside. The bolts should stick out away from the body.

Step 7 — The Fist

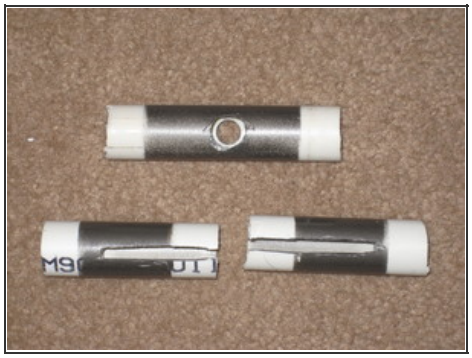
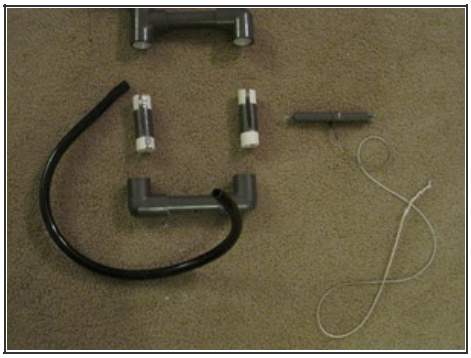

- The fingers of the fist are made from pipe insulation. We cut the fingers to slightly different lengths to resemble the different lengths of human fingers. The longest was 7".
- Cut the fingers and then cut notches on the insides of the fingers, opposite where the knuckles would be. The notches allow the fingers to bend more realistically.
- Line up the base of the fingers and run a thin, stiff wire through the base of them, fold the fingers over in a fist, then run the wire back through the fingertips and back to the start (complete the following before twisting/cutting the excess wire).
- Push the base of the middle finger onto the PVC sticking out of the connector. The wire inside of the finger will have to be bent up or down to allow the PVC to slide in. Finally, twist the wire together at the ends and cut off the excess.

Step 8 — The Hand



- There was a project a while ago in Make Magazine for building large robot fingers out of notched straws taped to your fingers (see Make Vol.19 Howtoons). This hand works the same way. The middle finger is the only one that is controlled; the others are attached to it and move when the middle finger is moved.
- Cut a length of pipe insulation for the middle finger (similar to the other hand) and cut three varying lengths of PVC pipe for the joints (the sum of these lengths should not exceed the length of the finger). The longest piece should be at the base where it will attach the finger to the arm.
- Push the pipes into the insulation leaving approximately 5/8"protruding on each end and the smallest one floating in the middle.

Step 9

- Next you'll need to make the handle designed to control the middle finger. The exact length of this should reflect the intended wearer's hand size. It should be made as big as the wearer's fingers can comfortably reach. The longer the draw on the handle, the more the fingers can flex.
- The PVC piece in the handle connected to the hose has different size holes on either side (see top of Frame 2). On one side it is wide enough for the hose to fit into, though the hose should not protrude from the other side of the PVC. Therefore, the hole opposite the hose hole needs to be just large enough for the twine to fit through.
- The handle consists of a dowel with screws at either end. The screws slide along slots on the side PVC pieces (visible in Frame 3). The slots should be made wide enough for the handle to slide smoothly. We used 1/2" dowel and 1" wood screws for the handle. The grinding wheel attachment for the dremel was used to make the slots.
- Drill another hole through the arm just before the connector, large enough for the hose to fit in.(frame 1, bottom left)
- Tie the twine around the handle and put the screws in the slots.
- Spray some silicone onto a rag and use it to lubricate the twine. Spray some more into the hose for good measure. Then work the twine down through the hose.
- Push the hose into the handle and the end of the arm.

Step 10

- Run the twine through the assembled middle finger and attach the finger to the arm. The insulation probably won't slide past the connector but if it looks like it will you can wrap a wire around it at the base like I did.
- Pull the twine tight through the finger, even flexing the finger some. Then attach the finger end cap catching the string.
- Cut three more lengths of insulation for the remaining fingers and put notches opposite where the knuckles belong like you did for the fist.
- Run wire through the three joints of the fingers. We used pipe cleaners because they were handy and I figured they'd be hidden by the hand but smaller wire might look nicer.

Step 11 — The Feet

- The feet are made from the two gallon buckets. We were afraid that he might fall through the bottom of the bucket so we reinforced them with some 1/4" plywood that rests on the bottom ridge which is stronger.
- Trace the bottom of the bucket on the plywood and cut it out with a scroll saw or coping saw. Drill 4 holes through the plywood and bucket and attach with 1" bolts. Make sure the plywood rests completely on the rim.
- In the pictures there is a square of sheet metal also on the feet. This was something added for an earlier design that didn't work out but we thought it looked nice and left it on. It isn't necessary.

Step 12

- Put a sneaker on top where you want his foot to be and draw a line on either side where the sneaker narrows. This is where the strap will attach.
- Cut out the holes for the strap. Mine were about 1" long and 1/4" wide. I used a drill and a Dremel grinding wheel to get it done.
- Run the strap down through one hole, up through the other, back down through the first and up through the other once more. This should give you a loop on the top to slip the sneaker into and 2 straps to tie together over the shoe to tighten.
- Caution: If the wearer's foot is at all loose on the bucket, this greatly increases the chance of tripping, falling, twisting an ankle or some other such harm.

Step 13

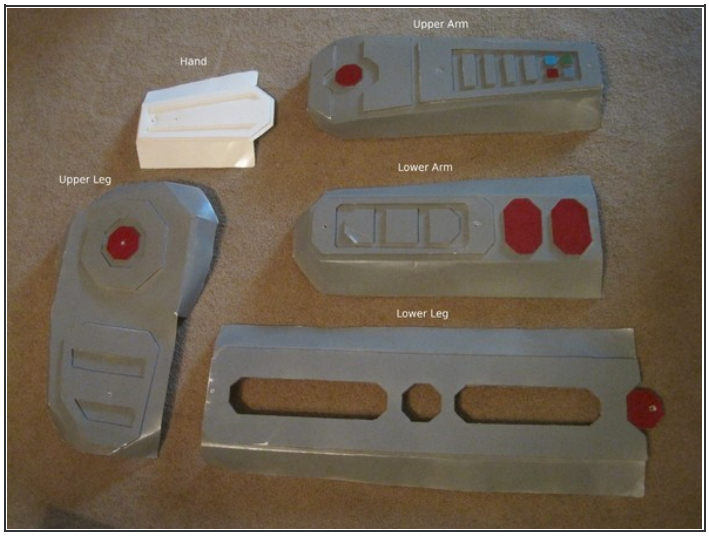


- We learned early on that the bucket feet were strong enough but were a little too easy to trip in so we decided to widen the base.
- Cut off the top of the two 5-gallon buckets at 4 1/4". Squeeze the rim so that it forms an oval around the 2 gallon bucket and drill 3 holes through both buckets on both sides. Connect the buckets with the #10-32 2" bolts.
- We also knew he would spend some time indoors on linoleum floors so we cut up some no-skid shoe pads and attached them around the rim of the inner bucket to decrease the slippery aspect of the buckets.

Step 14 — The Legs

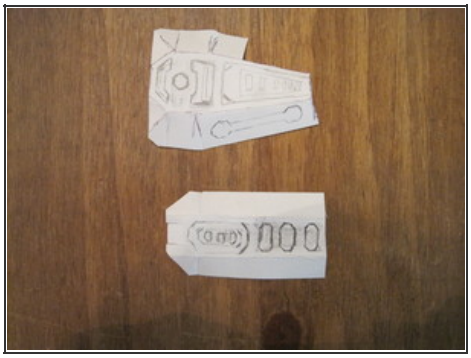
- The legs are very simple. Really they are just decorative so you can decide the length of the section yourself. We thought a longer lower leg looked nice and decided on 12" and 29".
- Cut a 29" and a 12" piece of PVC. The holes on the long piece are drilled at 1/2" from the ends. On the short piece they are drilled at 1/2" and 3/4". The 1/2" end is connected to the long piece with a 4" bolt. The bolts should stick out away from the body.
- Line up the long piece with the center of the outside of the foot (along the side of the bucket) and drill a hole through the foot. Attach with a 3" bolt.
- Put a 3" bolt through the other side of the short piece.

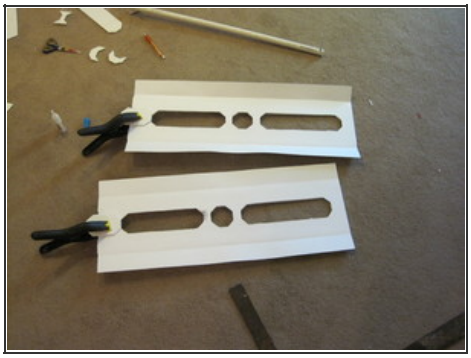
Step 15 — The Facade



- The facade is what makes the costume look like a robot rather than a collection of PVC pipes. It is made out of poster board and foam core board. The poster board is cut and folded into the shapes you want and then the foam core board is cut into decorative shapes and glued to the poster board (see Step 16). The foam core serves 2 purposes: decoration and strengthening the poster board.
- We made one piece for each of the limb sections and an additional piece for each hand.

Step 16





- Measure the poster board against the joints to make sure your design is long enough and mark where the bolts will go through. The exact shapes don't really matter, except that the foam shapes you put on will help stiffen and strengthen the poster board. Since they provide a stronger attachment point for the bolts, I tried to make sure they would span the bolts and a limb section. Other than that, this is where you get to be creative. I found it helpful to design them first using index cards.
- Cut and fold the poster board to shape, glue and clamp where necessary (see Frame 2). After the poster board is dry, cut out the foam shapes and glue them to the facade. I used tacky glue.
- In the third picture you can see that the poster board wasn't quite long enough to span the lower leg section so we attached a decorative piece of foam board to lengthen it.

Step 17 — Paint

- The next step is to paint. We chose gray metallic spray paint for the skeleton and a brighter gray paint for the facade.
- We then used acrylic paint to add highlights by painting some of the foam board pieces.
- Finally we coated all of the poster board pieces on both sides with a few coats of clear acrylic sealer in hopes of making it at least somewhat water-resistant.

Step 18 — Attaching the Facade

- Match the facade pieces with the limb sections, mark where then bolts will go through and drill holes for the bolts.
- All of the bolts are in place for the facade except those for the hands. Place the hand facades where you want them and then drill two holes through them and the arm PVC. Put 2 bolts in each hand facade. We used the #10-24 2" and 1.5" bolts.
- Put a nut and then a washer on the joint bolts and slide the facade piece on. Then put another washer and a nut on top.
- With our design we put the hand facade on first, followed by the lower arm and then the upper arm. The upper arm facade edges are bent down so we had to cut part of the edge off to allow the joint to work smoothly. (you can see where we cut on step 15, frame 2)

Step 19

- Here you can see our finished arm and leg.

Step 20 — Assembly



- In order to attach the arms and legs to the frame we wanted joints that were very flexible and not restricting. We decided on a string to connect the PVC end caps.
- Take the end cap off of the top of an arm and one end of the shoulder off of the frame. Drill a hole through the middle of each end cap just wide enough for the rope. Then drill a hole through one side of the upper arm PVC a little bit below how far down the end cap will reach.
- Push the rope through the hole in the PVC and down through the opening. I put the wire in the picture because that is what I ended up using to get the rope out more easily.
- Next put the rope through both end caps. Tie a stopper knot on the end with the end cap. I ended up using Ashley's stopper knot because it's nice and bulky but a figure eight or even an overhand should work if you drilled the hole small enough.
- Attach the end cap to the arm PVC and then pull the rope tight. Pull it as tight as you can because it's going to loosen after you tie the knot. Tie a stopper knot on the arm side of the rope and then cut off the excess. Attach the end cap back to the shoulder and then repeat with the other arm.

Step 21

- The hip joint is similar to the shoulder joint but with only one end cap.
- Drill a hole all the way though the thigh PVC above the bolt.
- Remove the end cap from one end of the hip piece of the frame. Drill a hole through the end cap.
- Run a piece of rope through the end cap and the thigh PVC. Tie a stopper knot on the end with the end cap first. Then pull the rope tight and tie a stopper knot on the other end.
- Reattach the end cap to the hip piece.
- The nuts will slowly work their way off the bolts if you don't do something to stop them. We could have used thread locking fluid or locknuts but we didn't need the costume to last forever and I knew I'd want to be able to take it apart. Since there is no real force pushing the nut off, just vibration, I just ended up winding a little duct tape above each nut on the bolt.

Step 22 — Go Trick or Treating



- Our son only fell once while trick or treating when he stepped off the sidewalk and onto a 4" high garden border. It was a slow fall and he didn't get hurt at all but we were prepared anyway. We definitely worried about the possibility of a hard fall without the ability to catch himself, so we made him wear his rollerblading knee pads, wrist guards and helmet.
- We live in a townhouse development where everyone has a porch. Unfortunately there was no way the costume was climbing steps. Luckily his robot arms were long enough that he could reach up to the door to get his candy after his sister rang the bell.
- The costume looked great and he got tons of compliments! Be prepared to take your time and have fun in your mech warrior costume.

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